NIRT: Collective and Quasiparticle Properties of Nanoparticles and Their Arrays, DMR-0210383

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Quantum Growth of Co Magnetic Nano-platelets on Si(111) Substrates

- Triangular shape Co platelets with lateral size quantized in units of 2.7 nm.
- All platelets have an identical height of 2 ML.
- Epitaxially grown on Si(111) 7x7 surface that are decorated with an ordered array of Al-clusters.
- Remarkably high blocking temperature (> 100 K) for ultra-small nano-magnets (a few nm^3).
- A platform with potential to integrate information storage and information processing.

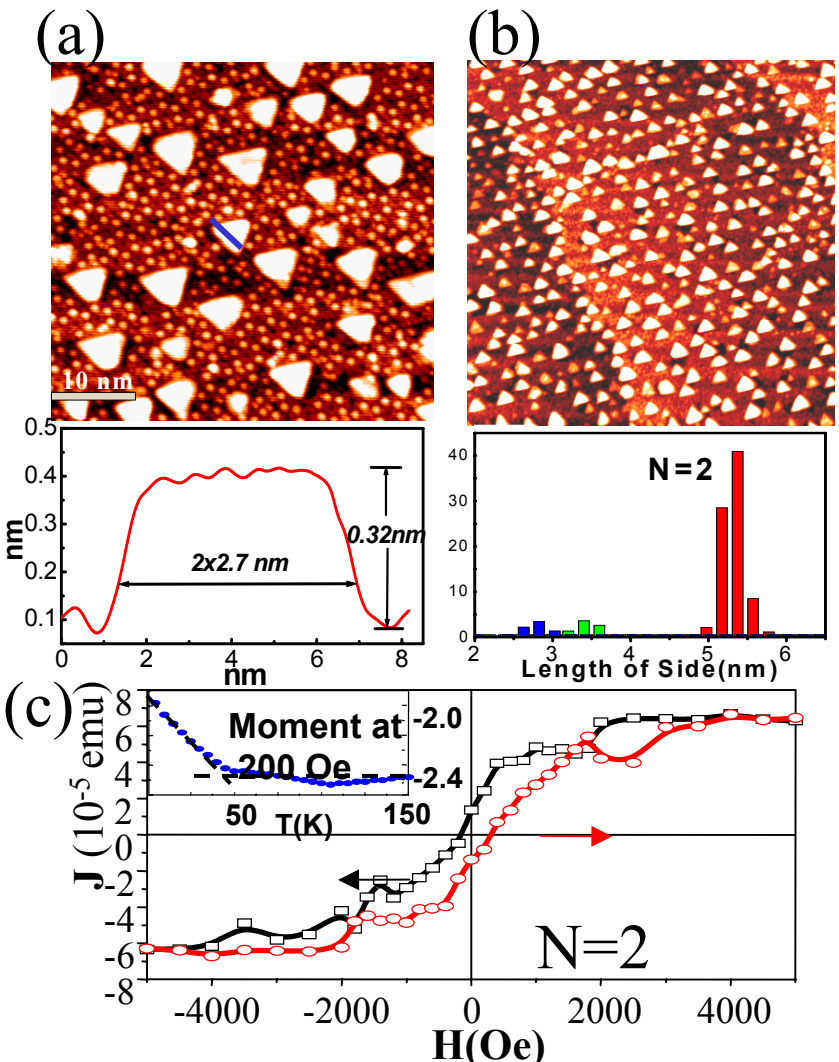

Fig.1 (a) The STM image (50 nmx50 nm) showing that the Co platelets are triangularly shaped with the lateral size quantized in unit of 2.7 nm which is the lattice parameter of the Si (111) 7x7 surface unit cell. Moreover, these platelets have an identical height of 0.32 nm which is 2ML (shown as the line profile below) (b) Large STM image showing that these platelets have a very narrow size distribution. Statistically, 90% of the platelets have the same lateral size of N=2. (c) The M-H hysteresis loop measured using a SQUID magnetometer at 5 K for an N= 2 sample (i.e. sample covered with more than 90% N=2 platelets). The inset showing the remanent magnetization versus temperature curve, indicating a blocking temperature of around 45K. Measurements on a N=3 sample show a blocking temperature of higher than 100K.

Nanometer-sized magnetic particles have attracted considerable attention due to the potential technological impacts in high density recording. To realize such application, a very critical challenge is to engineer a nanomagnetic system with high blocking temperature. Also, for obvious technological advantages, there is a strong driving force toward fabrication of magnetic nanostructures on Si substrates which in turns presents enormous technical challenges. Here we report a novel approach to fabricating a striking form of nanomagnetic materials on Si substrates with unusually high blocking barrier. Through a delicate combination of substrate-induced self-assembly and quantum engineering, we obtain large arrays of Co nanoplatelets (named after their extremely planar geometrical shape) with a singular height and quantized lateral sizes, all possessing triangular shape and unique orientation. In spite of their small volumes (only a few nm3), these nanomagnets exhibit remarkably high blocking temperatures (> 100 K). The achievement of epitaxial growth of nanomagnetic systems on Si substrates offers a potentially powerful technology platform, integrating information storage and data processing in a single chip.

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Education:

12 Graduate and 2 undergraduate students were supported or partially supported by this grant. 1 postdoc fully was supported and 3 other postdocs were partially supported. Dr. Jairo Sinova (the postdoc fully supported by this grant) is now an assistant professor at the Texas A&M University

Outreach:

The PIs have played critical role in facilitating campus wide education in nanoscience and technology. For example, Korgel led the effort establishing a graduate portfolio program in nanoscience and technology. All PIs helped organizing the annual Nanonight at the University of Texas where 15 posters were contributed from this NIRT program.